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Short Report

Skeletal asymmetry

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Abstract

Bilateral variations in dimensions of upper and lower limb bones are attributable to difference in mechanical stress and strain that the bones are subjected to during bone growth, and is referred to as directional asymmetry. This skeletal asymmetry in the upper limbs is usually prominent on the dominant side while in lower limbs on the other side, possibly due to supportive contra lateral muscle contractions, that influence the bone growth. This contra lateral dominance in upper and lower limbs is known as cross-symmetry pattern.

During skeletal remains examination, variations in different dimensions of long bones of an individual can result in erroneous opinion regarding number of individuals, especially in case of mass disasters. A case report of skeletal remains examination with review of relevant literature is presented where the different dimensions of right and left limb elements are measured and compared.

Keywords: Skeletal asymmetry; Directional asymmetry; Cross-symmetry pattern; Skeletal remains; Mass disasters

1. Introduction

Human body, which appears symmetrical along the midline grossly, is in fact asymmetrical both morphologically and physiologically. While externally there is a difference in bilateral dimensions of various body parts and musculature, internally it is due to asymmetrical positioning of viscera as well as variations in bilateral skeletal dimensions.

Bilateral variations in upper and lower limb bones are attributable to difference in mechanical stress and strain over different bones during its growth, and referred to as directional asymmetry. While one side of the upper limb, as observed is typically more developed or dominant, the lower limb opposite the dominant upper limb is larger as compared to other lower limb. This pattern of asymmetry in relation to dominant side in the upper limb has been observed in the length and weight of bones. In lower limbs, this is possibly due to supportive contra lateral muscle contractions that influence the bone growth. This contra lateral dominance in upper and lower limbs is known as cross-symmetry pattern. This crossed symmetry pattern in upper and lower limbs is characteristically found in hand length, muscle bulk, bone lengths, cortical dimensions, bone weights and articular surfaces.[1–4]

During the examination of skeletal remains, an essential preliminary investigation to be carried out is regarding the opinion on the number of individuals to whom the remains belong, especially in case of mass disasters. Opinion regarding the same is usually based on duplication, age, sex, various dimensions viz. length and weight, articulation with respective joints and serology of bones.[5]

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2. Case summary

In July 2004, Police recovered a partially skeletonised body from a forest area in Southern Karnataka. Medicolegal autopsy was performed and a set of bones were sent to Kasturba Medical College, Manipal for an opinion. Bones included skull with mandible, vertebrae, right hip bone, right fibula, right and left humerus, ulna, femur, and tibia. The bones were wet, yellowish brown in colour, with cartilaginous attachments at articular surfaces and decaying odour. Maggots and pupae were present all over the bones. Expert opinion was primarily sought for the identification and cause of death of the deceased.

After preliminary examination, all the bones were treated with 10% sodium hypochlorite solution for two days and reexamined in detail. Examination of the skeletal remains revealed that the bones belonged to a male aged about 50 years. Sex was determined based on inspectional method of sexually dimorphic morphological traits in skull, hip bone, and femur. Estimation of age was based on fusion of ossification centres in long bones, symphyseal changes on the articular surface of the pubis, and closure of cranial sutures. Stature of partly skeletonised body was roughly estimated at the recovery site by the autopsy surgeon to be between 172–176 cms. The same was confirmed based on multiplication factor derived for femur in south Indian population by Mehta and Thomas.[6]

Different measurements of both the upper and lower limb bones were taken with help of calipers; osteometric board and weighing machine. Among the various dimensions of the upper and lower limb bones, humerus and ulna showed obvious increase in length on the right side whereas tibia showed an increase in length on the contra lateral side (Table 1). With regards to the comparative weights of the bones humerus, ulna and tibia were heavier on the right side (Table 2). While other dimensions showed marked variations in the upper limb bones, either no or minimal variations in the dimensions of the lower

Table 1
Comparative length of long bones in mm

Right	Bone	Left
337	Humerus	330
289	Ulna	282
479	Femur	478
403	Tibia	410

Table 2
Comparative weight of long bones in grams

Right	Bone	Left
161.4	Humerus	147.5
75.0	Ulna	68.0
465.3	Femur	466.2
331.0	Tibia	320.6

Table 3
Comparative dimensions of the long bones

Bone	Dimensions	Right	Left
Humerus	Head circumference	14.0 cms	13.7 cms
	Vertical head diameter	7.5 cms	7.3 cms
	Max. Shaft circumference	7.2 cms	7.0 cms
	Distal articular breadth	6.3 cms	6.2 cms
Ulna	Supinator crest	More prominent	Less prominent
	Supinator fossa	Deeper	Less deep
Femur	Head circumference	14.9 cms	14.9 cms
	S-I Head diameter	4.7 cms	4.7 cms
	Bicondylar breadth	8.3 cms	8.4 cms
Tibia	Bicondylar breadth	7.6 cms	7.7 cms
	Distal M-L articular breadth	4.3 cms	4.3 cms
	Distal A-P articular breadth	3.0 cms	3.0 cms

S-I = Superio-inferior, M-L = Medio-lateral, A-P = Antero-posterior.

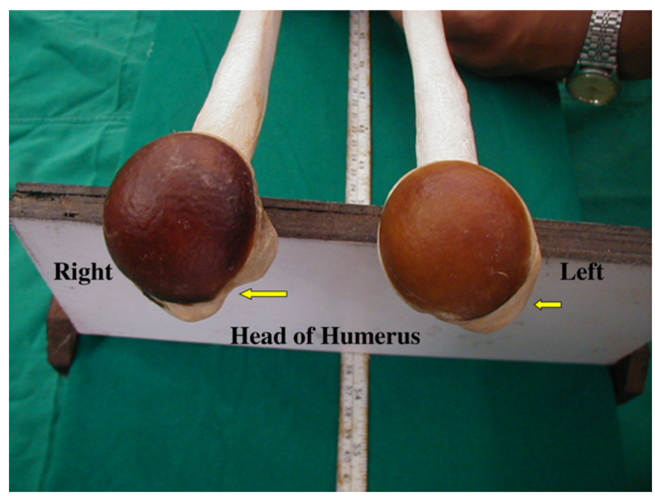

Fig. 1. Bilateral variations in the head of humerus.

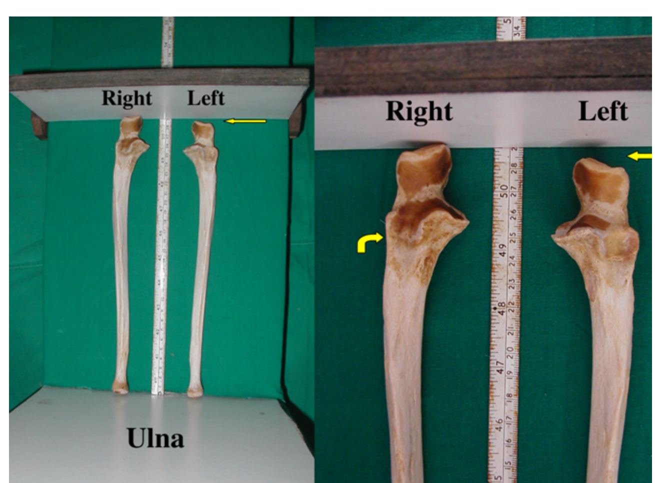

Fig. 2. Bilateral variations in the upper end of ulna.

limb bones (Table 3). Variations in the articular surface of upper arm bones are shown in Figs. 1 and 2.

3. Discussion

More stress and strain on the dominant side, depending on the occupation, may cause differences between the sides, often referred to as directional asymmetry. The length and circumference of long bones of dominant arm tend to be slightly more as compared to those of the other arm.[5] Mechanism of this skeletal asymmetry is the bone growth response to loading just like disuse of a limb leading to atrophy. On exposure to repeated high levels of mechanical loading, bones respond by growing more vigorously and increasing in density.[7] This skeletal asymmetry is larger for the upper limb as compared to lower limb and probably related to bipedal locomotion in humans. Upper limb joints are more exposed to mechanical loading because of frequency of activities conducted with the dominant upper limb, whereas lower limbs experience roughly equal magnitudes of mechanical loading.[8,9]

Directional asymmetry is more marked in upper limbs than the lower ones. Humerus and tibia showed greater skeletal asymmetry for upper limb and lower limb bones, respectively. Skeletal asymmetry is more significant in humerus while it was least for femur. Skeletal asymmetry in the right upper limb and left lower limb in an individual indicates cross symmetry pattern. This pattern of asymmetry with regard to length and weight of long bones has been reported in earlier studies by Latimer et al. and Cuk et al.,[10,11] whereas with regard to articular surface dimensions similar pattern was observed by Plochocki and Kennedy.[3,12] Besides long bones, directional asymmetry has also been reported in clavicle and sacrum.[13,14]

This is a case report with apparent differences in length, weight, and articular surface dimensions between the sides, thus the results should not be interpreted as generalization. The paper highlights on the fact that variations in the dimensions of long bones due to directional asymmetry may lead to erroneous opinion as to the number of individuals to whom the skeleton belongs especially in cases of mass disasters where a number of bones are brought for opinion. Hence, final opinion in such cases should be based on other corroboratory findings.

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